09/830658
8/PRTS
JC18 Rec'd PCT/PTO 30 APR 2001

Interference analysis for a mobile radio network comprising adaptive antennas

Description

The invention relates to a method for interference analysis for a mobile radio network having adaptive antennas in at least some radio cells and comprising traffic channels and control channels.

In mobile radio networks, frequencies for traffic channels and control channels are issued several times, interference between traffic or control channels in one radio cell and control or traffic channels in another, for example, adjacent radio cell being permitted only up to a predetermined threshold value and any interference going beyond the threshold value being avoided in the frequency allocation to control channels and traffic channels which is based on interference analysis.

From the publication "A Heuristic Technique …", IEEE Transactions on Vehicular Technology, 1979, Frank Box, an interference analysis for radio network planning in a mobile radio network is known.

The object of the present invention is an interference analysis which provides in as simple and efficient a manner as possible for radio network planning in a mobile radio network comprising adaptive antennas in at

least some radio cells. The object is achieved by the subject matters of the independent claims.

The method according to the invention permits an efficient and high-quality, computer-aided interference analysis adapted to the peculiarities of a mobile radio network comprising adaptive antennas.

By using an adaptive antenna in a radio cell, the interference from and in this radio cell can be reduced. The adaptive antenna exhibits a number of highly directional antenna patterns (called beams in the further text) which can be separately activated in each case and cover adjacent overlapping local areas. A single directional beam is activated for each frequency and TDMA timeslot of the radio cell. Although the traffic channels for a radio cell are radiated via adaptive antennas of the base station of the radio cell, the control channels of a cell are sent out, as a rule, by a conventional antenna having a coverage area over the entire cell in order to make it as simple as possible to obtain a uniform reception of the control signals in the cell.

The method according to the invention and the frequency planning device according to the invention permit an efficient high-quality interference analysis of a mobile radio network comprising such antennas which can be performed with computer assistance.

Further features and advantages of the invention are obtained from the subclaims and subsequent description of an exemplary embodiment, referring to the drawing, in which:

Figure 1 shows the planning process for a conventional mobile radio network as a flowchart,

Figure 2 shows the definition of channel-dependent interference matrices for a conventional mobile radio network comprising traffic channels and control channels,

Figure 3 shows the modeling of an adaptive antenna by a number of highly directional antennas having in each case a different antenna pattern (beam),

Figure 4 shows the different entries for the interference between two radio cells obtained on the basis of the modeling in figure 3,

Figure 5 shows the calculation of the probability of interference between a cell having an adaptive antenna and a cell having a conventional antenna,

Figure 6 shows the calculation of the probability of interference between two radio cells having in each case an adaptive antenna,

Figure 7 shows the procedure in determining the channel-dependent matrices, taking into consideration adaptive antennas,

Figure 8 shows the modified planning process.

Figure 1 shows the flow of the radio network planning process according to the analytical method for a conventional mobile radio network as a block diagram. After the radio network 1, the field strength prediction 2 and the cell area calculation 3 have been configured, a traffic calculation 4 and a channel request calculation 5 is performed per cell on the one hand, and, on the other hand, an interference analysis 6 of the interferences between the calculated (3) radio cells and a compatibility analysis 7 on the basis of calculated interferences (6) is performed, whereupon frequencies 8 are assigned to the radio cells.

Figure 2 shows the base stations *BSi* 9 and *BSj* 10 for two cells of the mobile radio network. Both cells send and receive voice information via traffic channels TCH and radiate control information via control channels BCCH etc. However, the signals of the traffic channels TCH and control channels BCCH of the cell with *BSi* also inadvertently reach the cell with *BSj* and interfere with the signals sent out by *BSj* 10 on traffic channels and control channels. In doing so, traffic channels TCH of *BSi* and traffic channels TCH of *BSj* interfere (matrix_tt) with one another. As well, control channels BCCH etc. of *BSi* and *BSj* interfere (matrix_bb) with one another. Furthermore, the traffic channels of one cell in each case interfere (matrices_tb and _bt) with the control channels of the other cell.

To perform this interference analysis, the extent of the interference of user signals (= carrier = c) sent out in a cell with respect to the local intensity of the interference signals (= interference = I) sent out from another cell is investigated for TCH and BCCH in the entire mobile radio network. If the interference between two cells is too great, a co-frequency exclusion is defined for these two cells. In this arrangement, different threshold values (for matrix_tt, _tb, _bt, _bb) can be defined for the just permissible interference between two cells with regard to traffic channels TCH and control channels BCCH etc. The reason for this is the BCCH carrier is emitted with full power since important information is radiated on it. As a consequence of this situation, no interference-reducing measures such as, e.g. power control or frequency hopping, have any effect on a BCCH carrier. Due to the important information radiated via the BCCH, however, a BCCH carrier is also subject to a higher requirement for noise immunity than a TCH carrier.

The ratio between the interference with a user signal in one cell from signals radiated in from other cells is also called carrier-to-interference-ratio or interference ratio of user signal C to interference signal I.

Adaptive antennas have a relatively narrow coverage area per TDMA timeslot. Conventional interference analysis methods for analyzing the interference between a cell

comprising an adaptive antenna and another cell with or without adaptive antenna are not easily suitable.

Figure 3 shows the modeling of a base station with an adaptive antenna 9 by n different base stations having in each case a highly directional antenna, selected in the method according to the invention. The individual beams of these antennas are identified by reference symbols 11 to 18. The adaptive antennas provide for a reduction in the inter-cellular interferences since only a part area of the corresponding sector area is radiated for each TDMA timeslot. On the basis of this modeling, steps 2 to 6 of the planning process in figure 1 can be carried out.

As illustrated in figure 4, this results in *n* entries in the interference matrix *I_tt*, for example for the interference between the radio cell of *BSi* (with adaptive antenna) and the radio cell of *BSj* (without adaptive antenna). For example $I_{in,j}$ 19 designates the probability of interference of the traffic channel signals radiated by *BSj* 20 with the traffic channel signals of the cell corresponding to beam n 21.

Analogously, *(n x n)* entries in the interference matrix are obtained for the interference between two cells, both of which are equipped with adaptive antennas. Since, however, one entry is in each case needed for the probability of interference from one cell to another for the compatibility calculation, the individual entries in figure 4 must be

combined to form a single entry, taking into consideration the timeslot-oriented activation of the individual beams, which entry represents the equivalent probability of interference between the two cells.

Figure 5 shows the determination of the equivalent interference probabilities $I_{i,j}$ 22 for the interference of traffic channel signals from a conventional antenna of the base station *BSj* with the traffic channel signals of a base station i equipped with an adaptive antenna. T_{ib} 23 here designates the traffic volume in this part-cell, the ratio of which to the total traffic 24 in cell i reproduces the probability for the activation of beam b. The equivalent interference probability thus provides the expected value for the probability of interference between cell i and cell j.

Figure 6 shows the determination of the equivalent probability of interference 25 between the cell with *BSj* and the cell with *BSi*, both of which are equipped with adaptive antennas.

Figure 7 shows a procedure in the calculation of the matrices *I_bb*, *I_tb*, and *I_bt*. Since the control channels in a radio cell with adaptive antenna are radiated by a conventional antenna having a coverage area of the entire cell, another interference analysis (compared with figures 5 and 6) must be used for the matrices *I_bb*, *I_tb*, and *Ibt*. For this reason, two configurations are considered at the same time in the interference analysis. On the one hand, the

configuration with the adaptive antennas (configuration A in figure 7) and, on the other hand, the configuration with the sector antennas (configuration B in figure 7). In addition to the calculations for configuration A (steps 2 to 6 in figure 1), calculation steps 2, 3 and 6 in figure 1 are carried out for configuration B. Matrix *I_tt* 26 from the calculation for configuration A according to the procedure in figures 5 and 6, is obtained for the end result. Matrix *I_bb* 27 is obtained from the calculation for configuration B. Matrices *I_tb* 28 and *I_bt* 29 are obtained from combining the mixed matrices 30, 31, 32 and 33. Thus, entry *(Ij, i)_tb* 34 is copied from matrix 30 and entry *(Ii,j)_tb* 35 is copied from matrix 32, for example for matrix *I_tb* 28.
Figure 8 shows the procedure in the radio network planning which is modified for a mobile radio network with adaptive antennas as a rough flowchart. Thus, modified interference matrices which take into consideration that, on the one hand, adaptive antennas of (at least some) radio cells of the mobile radio network have different main beam directions and thus different interferences with neighboring cells and on the other, control channels can also be driven uniformly for the radio cell in radio cells having adaptive antennas are calculated in step 36.